Evaluation of new plant disease control products for lettuce in Arizona

Michael E. Matheron and Martin Porchas, University of Arizona, Yuma Agricultural Center,
6425 W. Eighth Street, Yuma, AZ 85364

Abstract

Sclerotinia drop and powdery mildew are two important diseases of lettuce in Arizona caused by fungi. Sclerotinia drop can be caused by Sclerotinia minor and S. sclerotiorum. Moist soil and moderate temperature favor this disease. Some registered products as well as new chemistries in development were evaluated for control of lettuce drop during the winter vegetable growing season in 2002-2003. Sclerotia of each pathogen were applied to plots after lettuce thinning and just before the first application of test compounds. In plots infested with Sclerotinia minor, all materials tested at an appropriate rate significantly reduced disease. The best treatments included an application of Contans followed by an application of Endura (BAS 510), as well as two applications of the standard materials Ronilan and Rovral. Other useful products, when used alone, included Endura, Serenade, Pristine (BAS 516), Botran, Switch and Contans. In plots infested with S. sclerotiorum, two applications of Contans provided the best level of disease reduction among tested materials. Three applications of Endura or Pristine also were very efficacious. Other compounds that provided some reduction in disease caused by S. sclerotiorum included Botran, Serenade and Switch. Two of the products tested, Contans and Serenade, are biological control materials. For a valid comparison of products for control of Sclerotinia drop of lettuce, it is important to compare the results obtained from more than one field study. The reader is urged to review previous studies in addition to this report to get a true picture of the relative efficacy of tested compounds for control of Sclerotinia drop.

Powdery mildew on lettuce is caused by the fungus Erysiphe cichoracearum. This disease is favored by moderate to warm temperatures and dry weather conditions. Several potential new fungicides were evaluated for control of powdery mildew on lettuce in 2003. Powdery mildew appeared in our plots by Jan 9 and reached high levels by plant maturity on Feb 19. Compared to nontreated plants, all treatments significantly reduced the final severity of powdery mildew on lettuce statistically. However, only a limited number of compounds, such as Rally, Microthiol Disperss, Quinoxyfen, Flint, Zoxamide, Maneb, Pristine and Cabrio, provided the degree of disease control that would be of value to growers. The trial was intended to be a downy and powdery mildew trial; therefore, some of the treatments within this study were specifically included for downy mildew. No downy mildew developed; however, the downy mildew test products did offer some protection against powdery mildew. A field study also was conducted to evaluate 14 different cultivars of lettuce for potential resistance to powdery mildew. Cultivars Two Star and Big Green COS were very resistant to the disease. All other tested cultivars would have required application of fungicides to reduce the amount of powdery mildew to acceptable levels. On the other hand, planting lettuce cultivars with some disease tolerance may require less fungicide inputs to achieve acceptable disease control compared to planting very susceptible cultivars. Among tested cultivars, Slugger was most susceptible to powdery mildew.

Introduction

Sclerotinia drop and powdery mildew are two important fungal diseases of lettuce in Arizona. Sclerotinia drop is caused by *Sclerotinia minor* and *S. sclerotiorum*. As with other fungal diseases of vegetable crops, environmental conditions govern disease development. Mild to moderate temperatures and moist soil conditions favor drop; therefore, the incidence of the disease normally is highest from November through March in western Arizona lettuce fields. To minimize the occurrence of Sclerotinia drop, a fungicide treatment can be applied to the lettuce beds immediately after thinning when the plants are very small. This fungicide application, which can be followed in about 3 weeks by another treatment, forms a chemical barrier between the soil and the developing leaf canopy of the lettuce plant. With this chemical barrier in place, the bottom leaves and stem of each lettuce plant will be protected from colonization by the germinating sclerotia of the pathogens. Timely application of an effective fungicide is a critical component of an overall disease management strategy when lettuce is planted in fields with a history of Sclerotinia drop. Some new agrochemicals are in development that have activity on the group of fungal plant pathogens that includes *Sclerotinia*. Two other products are biological disease control materials; Serenade contains a bacterium (*Bacillus subtilis*) and Contans consists of a fungus (*Coniothyrium minitans*).

Powdery mildew, caused by the fungus *Erysiphe cichoracearum,* can develop rapidly in spring lettuce during March and April in western Arizona, when moderate to warm temperatures and dry environmental conditions prevail. However, the first signs of the disease can occur as early as December or January. Successful control of powdery mildew requires the presence of an effective fungicide on plants before onset of the disease. Successive applications of fungicides are required to maintain disease control until harvest. Sulfur can provide a significant degree of protection against powdery mildew if applied early and often; however, possible burning of lettuce leaves may occur when this product is applied at temperatures at or above 90 to 95EF. Several new plant disease control compounds are in development that have activity on the fungus that causes powdery mildew on lettuce.

In a continuing effort to increase the number of effective fungicides available to growers for management of Sclerotinia drop and powdery mildew, field studies were conducted during the 2002-2003 winter vegetable growing season to compare the efficacy of new chemistries to those currently available. Additionally, a field study was conducted to evaluate the relative genetic resistance of some lettuce cultivars to powdery mildew.

Materials and Methods

These studies were conducted at the Yuma Valley Agricultural Center. The soil was a silty clay loam (7-56-37 sand-silt-clay, pH 7.2, O.M. 0.7%). Sclerotia of *Sclerotinia minor* were produced in 0.25-pt glass flasks containing 15 to 20 sterilized 0.5 in. cubes of potato by seeding the potato tissue with mycelia of the fungus. After incubation for 4 to 6 weeks at 68EF, mature sclerotia were separated from residual potato tissue by washing the contents of each flask in running tap water within a soil sieve. Sclerotia were air-dried at room temperature, then stored at 40EF until needed. Inoculum of *Sclerotinia sclerotiorum* was produced in 2-qt glass containers by seeding moist sterilized barley seeds with mycelia of the pathogen. After a 2 month incubation at 68EF, abundant sclerotia were formed. The contents of each container were then removed, spread onto a clean surface and air-dried. The resultant mixture of sclerotia and infested barley seed was used as inoculum. Lettuce 'Winterhaven' was seeded and watered October 29, 2002 on double rows 12 in. apart on beds with 40 in. between bed centers. Treatments were replicated five times in a randomized complete block design. Each replicate consisted of 25 ft of bed, which contained two 25 ft rows of lettuce. Plants were thinned November 23 at the 3-4 leaf stage to a 12 in. spacing. After thinning, for plots infested with *Sclerotinia minor*, 0.13 oz (3.6 grams) of sclerotia were distributed evenly on the surface of each 25-ft-long plot between the rows of lettuce and incorporated into the top 1-inch of soil. For plots infested with *Sclerotinia sclerotiorum*, 0.5 pint of a dried mixture of sclerotia and infested barley grain was broadcast evenly over the surface of each 25-ft-long lettuce plot, again between the rows of lettuce on each bed, and incorporated into the top 1-inch of soil. Sclerotia were applied to plots on December 11. Treatment beds were separated by single nontreated beds. Treatments were applied with a tractor-mounted boom sprayer (flat-fan nozzles spaced 12 in. apart) that delivered 50 gal/acre at 100 psi. Test materials were applied to the surface of the bed and plants at the times described in the data table. Mean soil temperature (EF) at the 4 in. depth was as follows: Dec, 54; Jan, 56; Feb, 58. Total rainfall in inches was as follows: December, 0.00; January, 0.03, February, 0.57. Furrow irrigation was used for the duration of this trial. The severity of disease was determined at plant maturity (Feb 24) by recording the number of dead plants in each plot. As a point of reference, the original stand of lettuce was thinned to approximately 55 plants per plot.

For the powdery mildew fungicide evaluation trial, lettuce 'Winterhaven' was planted and treatments were replicated as described above. Each replicate consisted of 25 ft of bed, which contained two 25-ft rows of lettuce. Plants were thinned November 23 to a 12 in. spacing. Treatment beds were separated by single nontreated beds. Treatments were applied with a tractor-mounted boom sprayer that delivered 50 gal/acre at 100 psi to flat-fan nozzles spaced 12 in. apart. Foliar applications of test materials were made January 9 and 20 and February 4, 2003. Maximum and minimum ranges (EF) of air temperature were as follows: December (2002), 53-75, 30-50; January (2003), 68-87, 37-52; February 1 to 21, 62-84, 31-55. Maximum and minimum ranges (%) for relative humidity were as follows: December (2002), 72-100, 19-66; January (2003), 60-100, 13-46; February 1 to 21, 67-100, 9-89. Total rainfall in inches was as follows: December, 0.00; January, 0.03; 1 to 21 February, 0.57. Furrow irrigation was used for the duration of the trial. The severity of powdery mildew caused by *Erysiphe cichoracearum* was determined at plant maturity (19-21 Feb) by rating 10 plants randomly selected from each of the five replicate plots per treatment using the following rating system: 0 = no powdery mildew present; 1 = powdery mildew present on bottom leaves of plant; 2 = powdery mildew present on bottom leaves and lower wrapper leaves; 3 = powdery mildew present on bottom leaves and all wrapper leaves; 4 = powdery mildew present on bottom leaves, wrapper leaves and cap leaf; 5 = powdery mildew present on entire head. Yield loss due to rejected lettuce heads would normally begin to occur on plants with a rating above 2.0.

For the genetic resistance trial, 14 cultivars of lettuce were seeded and watered December 13, 2002 in double rows 12 inches apart on beds with 40 inches between bed centers. Maximum and minimum ranges (EF) of air temperature were as follows: December (2002), 53-75, 30-50; January (2003), 68-87, 37-52; February, 62-84, 31-55; March 1 to 26, 64-89, 38-58. Maximum and minimum ranges (%) for relative humidity were as follows: December (2002), 72-100, 19-66; January (2003), 60-100, 13-46; February, 67-100, 9-89; March 1 to 26, 76-100, 13-40. Total rainfall in inches was as follows: December, 0.00; January, 0.03, February, 1.15; Mar 1 to 26, 0.10. Furrow irrigation was used for the duration of the trial. The severity of powdery mildew caused by *Erysiphe cichoracearum* was determined at plant maturity (March 26) by rating 10 plants randomly selected from each of the five replicate plots for each lettuce cultivar using the rating system described earlier.

Results and Discussion

In plots infested with *Sclerotinia minor*, all materials tested at an appropriate rate significantly reduced disease (Table 1). The best treatments included an application of Contans followed by an application of Endura (BAS 510), as well as two applications of the standard materials Ronilan and Rovral. Other useful compounds, when applied alone, included Endura, Serenade, Pristine (BAS 516), Botran, Switch and Contans. In plots infested with *S. sclerotiorum*, two applications of Contans provided the best level of disease reduction among tested materials (Table 1). Three applications of Endura or Pristine also were very efficacious. Other compounds that provided some reduction in disease caused by *S. sclerotiorum* included Botran, Serenade and Switch. Two of the products tested, Contans and Serenade, are biological control materials. Contans is a strain of the fungus *Coniothyrium minitans* and Serenade is a strain of the bacterium *Bacillus subtilis*. For a valid comparison of products for control of Sclerotinia drop of lettuce, it is important to compare the results obtained from more than one field study. The reader is urged to review previous studies in addition to this report to get a true picture of the relative efficacy of compounds for control of Sclerotinia drop.

Statistically, all treatments significantly reduced the final severity of powdery mildew on lettuce (Table 2). However, only a limited number of these treatments provided a level of disease control that would be desirable and useful to growers. The trial was intended to be a downy and powdery mildew trial, so some of the treatments within this study were specifically included for downy mildew. No downy mildew developed; however, the downy mildew test products did offer some protection against powdery mildew. Some compounds (Actigard, Microthiol Disperss, and Quadris) were applied only on the second application date, so that the efficacy of these materials could be compared to an alternation with another chemical during the first and third application dates. For example, Actigard applied only at the second application date produced a disease rating of 3.1. When Quadris at the first and third application date was alternated with Actigard at the second application date, the disease rating was 2.3. Three applications of Quadris alone also resulted in a disease rating of 2.3. For resistance management, the Quadris label does not allow three sequential applications. The data from this trial suggests that an alternation of Quadris with Actigard would provide equivalent disease protection and allow alternation of chemistries as well. Such alternation programs will need to be tested over a multiyear period to determine if these preliminary results are consistently achieved.

Significant differences were detected among tested lettuce cultivars with respect to relative resistance to powdery mildew (Table 3). The cultivars Two Star and Big Green COS were very resistant to the disease. All other tested cultivars would have required application of fungicides to reduce the amount of disease to acceptable levels. On the other hand, planting lettuce cultivars with some disease tolerance may require less fungicide inputs to achieve acceptable disease control compared to planting very susceptible cultivars. Among tested cultivars, Slugger was most susceptible to powdery mildew.

Table 1. Sclerotinia drop of lettuce fungicide trial, 2003.
Michael Matheron and Martin Porchas, Yuma Agricultural Center, University of Arizona.

Treatment	Rate (lb a.i./A)	Treatment dates [1]	Diseased plants per 25 ft plot[2]	
			S. minor	*S. sclerotiorum*
Contans (water incorporation)[3]	4.0 lb prod.	1		
alternated with BAS 510 70WG	0.45	3	4.4	30.2
Rovral 4F	1.0	1,3	6.4	29.2
Ronilan 50DF	1.0	1,3	9.8	21.2
Endura 70WG (BAS 510)	0.35	1,2,3	10.0	16.6
Serenade AS (water incorp.)[3]	4.0 qt prod.	1,3	10.0	27.4
Pristine 38WG (BAS 516)	0.4	1,3	10.2	27.8
Botran 5F	1.87	1,3	10.8	24.6
Endura 70WG (BAS 510)	0.45	1,2,3	11.0	17.2
Pristine 38WG (BAS 516)	0.45	1,2,3	11.0	19.8
Botran 5F	3.75	1,3	11.0	28.2
Switch 62.5WG	0.43	1,3	11.6	27.6
Endura 70WG (BAS 510)	0.35	1,3	11.8	37.2
Switch 62.5 WG	0.56	1,3	12.4	30.0
Contans (water incorporation)[3]	4.0 lb prod.	1,3	12.6	12.8
Contans (water incorporation)[3]	2.0 lb prod.	1,3	16.8	18.2
Nontreated control	-------	-------	23.2	37.8
LSD (Least Significant Difference, *P*=0.05) [4]			5.0	8.4

1 Treatments were applied to soil on 1) Dec 12; 2) Dec 20; 3) Dec 31, 2002.
2 Disease assessment was performed at crop maturity on Feb 24, 2003. Each 25 ft. plot contained approximately 55 plants. All diseased plants were dead or dying.
3 Product applied to bed surface between lettuce rows in 1.0 gal of water per plot. An additional 1.0 gal of water was applied to further incorporate the product into the soil.
4 Values in each column differing by more than the least significant difference are significantly different from each other according to the Duncan-Waller K-ratio test.

Table 2. Powdery mildew of lettuce fungicide trial, 2003. Page 1.
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Treatment	Rate (lb a.i./A)	Treatment dates [1]	Disease rating [2]
Rally 40W	0.1	1,2,3	0.0
Maneb 75DF + Microthiol Disperss 80DF	1.5 + 4.0	1,2,3	0.0
Microthiol Disperss 80DF	4.8	1,2,3	0.0
Quinoxyfen (250 g/l)	0.167	1,2,3	0.0
Flint 50WG	0.125	1,2,3	0.0
Quinoxyfen (250 g/l)	0.11	1,2,3	0.4
Zoxamide 80WP	0.2	1,2,3	0.8
Maneb 75DF	1.5	1,2,3	1.2
Pristine 38WG (BAS 516)	0.4	1,2,3	1.3
Cabrio 20WG (BAS 500)	0.18	1,2,3	1.3
Foliar Supreme	3.0 qt. product	1,2,3	1.4
Actigard 50WG	0.03	1,3	
alternated with Quadris 2.08SC	0.25	2	1.7
Reason (500 g/l)	0.27	1,2,3	2.1
Quadris 2.08SC	0.25	1,3	
alternated with Actigard 50WG	0.03	2	2.3
Curzate 60DF + Maneb 75DF	0.187 + 1.12	1,2,3	2.3
Quadris 2.08SC	0.25	1,2,3	2.3
Curzate 60DF	0.187	1,2,3	2.3
Acrobat 50WP + Maneb 75DF	0.2 + 1.5	1,3	
alternated with Maneb 75DF	1.5	2	2.6
Acrobat 50WP + Maneb 75DF	0.2 + 1.5	1,3	
alternated with Aliette 80WDG	4.0	2	2.6
Reason (500 g/l)	0.18	1,2,3	2.7
Quadris 2.08SC	0.25	2	2.9
Microthiol Disperss 80DF	4.8	2	3.0
Milsana (0.5% v/v) + Tween 20 (0.02%)	0.25 gal + 19 ml prod.	1,3	
alternated with Microthiol Disperss 80DF	4.8	2	3.0
Actigard 50WG	0.03	2	3.1
DPX-KP481 50DF	0.375	1,2,3	3.1
Curzate 60DF + Maneb 75DF	0.187 + 1.5	1,2,3	3.2
Milsana (0.5% v/v) + Tween 20 (0.02%)	0.25 gal + 19 ml prod.	1,3	
alternated with Quadris 2.08SC	0.25	2	3.2
Acrobat 50WP	0.2	1,2,3	3.4
Actigard 50WG	0.03	1,2,3	3.5
Milsana (0.5% v/v) + Tween 20 (0.02%)	0.25 gal + 19 ml prod.	1,3	3.6
BAS 545 (400 g/l)	0.07	1,2,3	3.6

TABLE CONTINUED ON NEXT PAGE

Treatment	Rate (lb a.i./A)	Treatment dates [1]	Disease rating [2]
CONTINUATION OF TABLE FROM PRECEDING PAGE			
Actigard 50WG	0.03	1,3	3.7
Phortress	3.0 qt. product	1,2,3	4.0
Milsana (0.5% v/v) + Tween 20 (0.02%)	0.25 gal + 19 ml prod.	1,2,3	4.0
BAS 545 (400 g/l) + Kinetic	0.07 + 1.0 fl. oz.	1,2,3	4.0
DPX-KP481 50DF	0.25	1,2,3	4.1
BAS 545 (400 g/l)	0.05	1,2,3	4.1
Serenade AS	4.0 qt. prod.	1,2,3	4.1
Sonata AS	4.0 qt. prod.	1,2,3	4.1
Milsana (0.5% v/v) + Tween 20 (0.02%)	0.25 gal + 19 ml prod.	1,3	
alternated with Actigard 50WG	0.03	2	4.2
Nontreated control	-------	-------	4.4
LSD (Least Significant Difference, *P*=0.05) [3]			0.2

1 Treatments were applied on 1) Jan 9; 2) Jan 20; 3) Feb 4, 2003. Small powdery mildew colonies (2 to 3 mm in diameter) were first observed on some plants Jan 9.

2 Disease ratings were performed Feb 19 to 21. The severity of powdery mildew was determined by using the following rating system:
0 = No powdery mildew colonies present on plant.
1 = Powdery mildew present on bottom leaves.
2 = Powdery mildew present on bottom leaves and lower wrapper leaves.
3 = Powdery mildew present on bottom leaves and all wrapper leaves.
4 = Powdery mildew present on bottom leaves, wrapper leaves, and cap leaf.
5 = Powdery mildew present on entire head.

3 Values differing by more than the least significant difference are significantly different from each other according to the Duncan-Waller K-ratio test.

Table 3. Effect of cultivar on severity of lettuce powdery mildew in 2003 field trial.

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Cultivar	Lettuce type	Disease rating [1]
Two Star	Greenleaf	0.0
Big Green COS	Romaine	0.4
Van Max	Head	1.2
Sniper	Head	1.3
HMX 1528	Head	1.3
Desert Spring	Head	1.3
Diamond	Head	1.4
Jackel	Head	1.8
Telluride	Head	1.9
HMX 1527	Head	2.1
Durango	Head	2.2
Sunbelt	Romaine	2.5
Silverado	Head	2.6
Slugger	Romaine	3.8
LSD (Least Significant Difference, *P* = 0.05)		0.2

[1] Numbers followed by a different letter are significantly different (*P* = 0.05) according to the Duncan-Waller *k*-ratio (LSD) test.